Test and Evaluation in a Time of War: Making Defense Systems Reliable

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With our nation engaged in the historic Global War on Terrorism, every element of our national security apparatus must maintain a sharp focus on how to best aid this effort. Test and evaluation (T&E) is no different in this regard and is doing many things with the single aim of getting effective and suitable weapon systems to our warfighters in the field as quickly and efficiently as possible. To accomplish these goals, the T&E community is engaged on two fronts: first, we are responding to today's call for urgency in all we do to support the warfighter's operational needs; and second, we are working to effect lasting policy changes that will result in more reliable future defense systems.


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To ensure that systems designed to meet urgent operational requirements are deployed as quickly as possible and with as much confidence as possible, the T&E community has developed and is utilizing organizational commitment—and individual creativity—and flexibility. These characteristics are necessary ingredients because requirements and concepts-of-operations terms for urgently needed systems are often vaguely stated. Many times, the requirement is simply boiled down to "something better than what we have." Another characteristic of urgent operational requirements is shortened timelines, which often means fielding without the usual breadth of testing, because when threat operational modes change, our engaged warriors must have responsive systems immediately. When all of these factors are considered, it is obvious to see why the T&E community is working so hard to react to and accommodate shortened timelines that are consistent with meeting urgent requirements.

Why is it so important for us to ensure that our warfighters can employ new capabilities as quickly as possible and with as much confidence as possible? Because if a system cannot be counted on to perform when needed, not only is mission success jeopardized, but our warriors will develop doubts about the weapon system's performance, which can impact both individual and organizational mission performance.

The T&E community has responded to these challenges by sometimes working around the clock at ranges such as Yuma (Arizona) and Aberdeen (Maryland) to provide 24- or 48-hour turnarounds for information on critical equipment and systems, such as body and vehicle armor.

Testers are also working to help meet the urgent needs of our warfighters in the critical mission of defeating Improvised Explosive Devices (IEDs). For this urgent need, the Army Test and Evaluation Command (ATEC) has taken on the mission to plan, conduct and report the results of tests, simulations, experiments and evaluations to ensure that our warfighters have the right capabilities for success across the entire spectrum of operations. As part of these efforts, testers at ATEC are conducting rapid testing in direct support of the warfighter to provide information on the capabilities and limitations of untested weapon systems issued directly to our soldiers conducting combat operations. The Joint IED Defeat Organization (JIEDDO) expects testers to use flexible, streamlined and tailored test procedures that are based on standard test protocols. Examples include: reusing knowledge and data from other projects; sharing data among services and agencies; and providing concise and timely reports to enable decisions on fielding, improvement or termination.

Like the Army, the Air Force T&E community is working hard to be responsive to the urgent operational needs of our warfighters, and is providing rapid evaluations of components for urgently needed capabilities such as Integrated Base Defense Security, and Global Hawk and Small Diameter Bomb employment.

Report Documentation Page			*Form Approved* *OMB No. 0704-0188*
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.			
1. REPORT DATE **2007**	2. REPORT TYPE		3. DATES COVERED **00-00-2007 to 00-00-2007**
4. TITLE AND SUBTITLE **Test and Evaluation in a Time of War: Making Defense Systems Reliable**			5a. CONTRACT NUMBER 5b. GRANT NUMBER 5c. PROGRAM ELEMENT NUMBER
6. AUTHOR(S)			5d. PROJECT NUMBER 5e. TASK NUMBER 5f. WORK UNIT NUMBER
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Office of the Secretary of Defense,Operational Test and Evaluation,Washington,DC,20301**			8. PERFORMING ORGANIZATION REPORT NUMBER
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)			10. SPONSOR/MONITOR’S ACRONYM(S) 11. SPONSOR/MONITOR’S REPORT NUMBER(S)
12. DISTRIBUTION/AVAILABILITY STATEMENT **Approved for public release; distribution unlimited**			
13. SUPPLEMENTARY NOTES			
14. ABSTRACT			
15. SUBJECT TERMS			

16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT	18. NUMBER OF PAGES	19a. NAME OF RESPONSIBLE PERSON
a. REPORT **unclassified**	b. ABSTRACT **unclassified**	c. THIS PAGE **unclassified**	**Same as Report (SAR)**	**4**	

Standard Form 298 (Rev. 8-98)
Prescribed by ANSI Std Z39-18

The Navy T&E community also is responding across the entire spectrum of urgently needed warfighter capabilities, including efforts to evaluate and provide information on the Counter-Bomb/Counter-Bomber Advanced Concept Technology Demonstration, which will help meet evolving, asymmetrical and sophisticated terrorist threats. These detection and mitigation systems will provide force protection personnel with the latest concept of operations, tactics, techniques and procedures, as well as rules of engagement generation, update and dissemination.

Another way that testers are meeting the challenges of urgent operational requirements is through deployed Forward Operational Assessment (FOA) teams. FOA teams ensure that information needs are identified to state-side ranges and that the information supplied from the ranges is relevant and properly reported to our forces. This response by the T&E community is especially noteworthy because it often involves a level of commitment and sacrifice that is outside the typical T&E operating envelope, and it exemplifies the ends to which the T&E community is prepared to go to support our warfighters.

The second front on which the T&E community is engaged is the policy arena: to effect lasting policy changes that will result in more reliable future defense systems. This front involves efforts in the Pentagon, by the offices of the Director, Operational Test & Evaluation (DOT&E) and the Under Secretary of Defense for Acquisition, Technology and Logistics (USD[AT&L]), to develop and implement policies that will improve the reliability of systems that reach our warfighters through the traditional or formal acquisition process.

This effort is important because a large number of programs are not satisfactorily demonstrating that they meet reliability requirements, and poor reliability drives down mission accomplishment and affordability, as well as drives up force structure, total cost of ownership and the logistics footprint. This means that if a weapon system is dependent upon a component that is prone to failure, the affected military service must plan, organize, equip and operate in a manner to offset or accommodate the expected component failure. The resulting logistical footprint of components needed to replace a failed system include: the creation of redundant systems and the provision of spares that must be purchased, transported, stored and used to repair the system. These steps may require added personnel, tools, test equipment and training (or contract support) to find and replace the failed component and to return the system to service. Obviously, it is preferable to minimize operational down-time, costs and logistical footprint that result from insufficient system reliability.

Another frustrating issue that testers contend with in the reliability area is systems coming to test before they are sufficiently mature. Often, schedule considerations preempt methodical system technical development, and tests can begin while the system is still technically immature. Sufficient maturity in reliability is especially troubling, as test experience indicates. Looking at initial operational T&E (IOT&E) results, for which DOT&E reports to Congress, the trend is not good. From 2001 to 2005, the suitability performance rate for systems ranged from 33 percent to 60 percent of systems found not suitable in IOT&E. In the Army, from 1996 to 2006, 66 percent of systems failed to meet reliability requirements and, of those, 75 percent failed to meet one-half of the requirement. Navy testing in Fiscal Year 2007 resulted in more than half of its systems being found not suitable. A Fiscal Year 2007 breakdown of DT/OT events indicates that 43 percent of Air Force tests were slipped. In Fiscal Year 2006, 25 percent (two of eight) of the OTs that were started had to be stopped because of system deficiencies.

These unsatisfactory results add up to our forces not receiving the planned equipment improvements they need, because either the system fielding had to be delayed to fix suitability problems—most often the deficiencies are in reliability—or the choice was to field the system with its built-in lack of reliability. We know reliability deficiencies can compromise mission effectiveness, because as I mentioned previously, if an unreliable system cannot be counted on to perform when needed, then our warfighters will obviously doubt the system's performance, and this will erode overall mission success.

Deficiencies mean that part(s) of the system need to be reworked to get what was originally desired. In my experience in the private sector, it is this "rework" that is the big cost and schedule driver.

So, what can the test community do to reduce the rework problem? First and foremost, the deficiencies must be discovered and corrected as early as possible—IOT&E is too late. I have said that *"OT&E should be a time of confirmation, not discovery."* This is only possible if the systems engineering work of which reliability design and testing is an integral part is done up front. Emphasis on reliability testing needs to go beyond traditional tasks (that is, failure modes and effects analysis, failure reporting analysis and corrective action system,

environmental stress screening and burn-in, and so forth) to include physics of failure modeling and simulation (that is, fatigue analysis tools, finite element modeling, dynamic simulation, heat transfer analyses and so forth) and reliability design testing. Reliability design testing includes Reliability Enhancement Testing/Highly Accelerated Life Testing (HALT), Accelerated Life Testing, and environmental survey tests. Without comprehensive lower-level testing (for example, HALT) on most or all critical subassemblies, and without significant integration and developmental testing, it is unlikely that high levels of reliability will be achieved.

The significance of the suitability problem can be defined and measured in terms of the cost over the life cycle and the cost to correct the problem if it moves past the design process. This is why DOT&E has made improving suitability its first priority and has sponsored studies to determine the costs of unreliability, as well as the return on investment (ROI) that is possible with targeted reliability engineering. The results are striking.

One study found that reliability goals did not appear to be informed management decisions or the initial engineering effort. Another study also found significant re–design effort after the initial design was complete and the systems were through their IOT&Es. For the purpose of the studies, the late effort to correct problems had a special benefit, namely, the budget justifications called out the amounts spent correcting reliability problems after developmental and operational tests. With the ability to track the budget to improve reliability and the ability to calculate the reduced life cycle operating and support costs, each group could calculate the ROI. The ROIs for investment in reliability improvements were all greater than 4:1. The median reliability ROI was 15:1.

In 2005, a representative of the Defense Supply Center reported that the Defense Logistics Agency (DLA) Reliability program had similar results. The programs were smaller and focused on component improvements for aviation components in already fielded systems. In total, DLA provided $36 million from Fiscal Year 2003 to Fiscal Year 2005, for which it estimates a 10-year savings of $496 million, broken down as follows:

- Twenty-seven Army projects with $14.1 million funding with $187 million in estimated savings;
- Forty-five Navy projects with $9.7 million funding and $207 million in estimated savings; and
- Twenty-one Air Force projects with $8.3 million funding and $102 million in estimated savings.

While these projects were small, a 13.8 ROI is consistent with the findings for the larger and system-level findings of our studies.

DoD's Reduction of Total Ownership Costs (R-TOC) program is a slightly different example of what ROIs are possible. Fiscal Year 2005 cost avoidances were reported to be $2.1 billion, and projected life cycle cost avoidances will exceed $76 billion. The R-TOC program is Office of the Secretary of Defense (OSD)-led and Service-supported. It seeks to facilitate both new technologies and management practices to improve readiness and reduce ownership cost. Funding for R-TOC was provided from DoD through out-of-POM cycle sweep-up funding through three Program Budget Decisions (PBDs). The Services were not required to set up and fund R-TOC projects. The DoD funding total was approximately $40 million in these PBDs. So the billions in savings resulted from an investment of approximately $40 million, plus intensive management attention to improve techniques and procedures.

The R-TOC program addresses already existing systems. What ROIs are possible if the investment is done as part of the up-front systems engineering effort? In the cases where the investment occurred after the initial design was complete and often after the IOT&E, calculating the ROI was possible because the reliability improvement occurred after the initial design was complete, so the cost was separate from the initial systems engineering effort. Still, the reduction in operations and sustainment (O&S) cost was in the 23- to 86-percent range. There is evidence that an 80-percent reduction in O&S is not unreasonable to expect when the life cycle support costs are considered from the very beginning and design choices made accordingly. In a simulation of a complex ground vehicle electronics system, one study found that reliability improvement is the most significant factor in reducing the cost of ownership among the factors examined. The factors were reliability, commonality of parts (number of different configurations allowed), support system performance, packaging (that is, the use of line-replaceable modules versus line-replaceable units) and maintainability. However, when all factors were considered together and assuming best possible trades were made, an 80-percent reduction in overall support cost might be possible—which can produce billion-dollar savings.

In one case (Force XXI Battle Command, Brigade-and-Below), the improvement in reliability decreased the expected 20-year support cost from $13.6 billion to $1.8 billion (an 86-percent reduction). In another case,

the Air Force post-IOT&E investment in reliability improvements for the F-22 are expected to reduce the costs from $30 billion to $25 billion, based on the current expected buy of 182 total active inventory aircraft (with a 148 primary aerospace vehicle authorization) and a 24-year life. If the buy were bigger or the life extended (as is often the case for defense systems), the savings would be greater.

Because efforts and investments to improve reliability must happen before IOT&E and in the early developmental phases, DOT&E and USD(AT&L) have developed a key partnership that is working to identify and exploit opportunities to formulate new policies for improving reliability. These joint efforts have so far included: sponsorship of an updated DoD Reliability, Availability and Maintainability (RAM) Handbook: joint sponsorship of a congressionally mandated report on current T&E policies and practices and how they can be improved: and joint sponsorship of a Defense Science Board taskforce on Developmental T&E (DT&E) that will examine how to strengthen DT&E oversight. DOT&E and USD(AT&L) are also working together to provide some guidance for the development of the mandatory Key Performance Parameter for Materiel Availability.

Working with the Joint Staff and USD(AT&L), we have initial agreement on a method for developing and justifying RAM requirements. This will provide a sound basis for the requirement, and the logistical conditions for system employment that would be a valid basis for test. Another ongoing joint effort is to look at the system development contracting process—specifically the request for proposal to industry, and determine how to include reliability requirements in the system development statement of work.

So these are just a few of the ways that the T&E community has answered the call to remain focused on our brave airmen, soldiers, sailors and marines as they sacrifice and risk all to defend our nation against enemies that are determined to undermine and destroy it. To me, the striking characteristic of the national security community of which T&E is a part is how the old parochialisms seem to melt away as we all become united and focused on supporting our warfighters. It is in these times that we cease to become developmental testers, or operational testers, and instead become just plain testers, looking for the best way to meet the urgent operational needs of our men and women at war, and to do what makes the most sense to deliver them the best systems possible. In the final analysis, we do not serve the acquisition community; we serve the men and women who are protecting our freedoms with the equipment we deliver to them. ❑

Dr. Charles E. McQueary was sworn in as Director of Operational Test and Evaluation on July 27, 2006. A Presidential appointee confirmed by the U.S. Senate, he serves as the senior advisor to the Secretary of Defense on testing of Department of Defense weapon systems, prescribing policies and procedures for the conduct of operational and live fire test and evaluation. Prior to this appointment, Dr. McQueary was the first Under Secretary for Science and Technology at the Department of Homeland Security and confirmed by the U.S. Senate in March of 2003. In this position, he led the research and development arm of the department, utilizing the nation's scientific and technological resources to provide federal, state and local officials with the technology and capabilities to protect the homeland. Dr. McQueary is a former president of General Dynamics Advanced Technology Systems, Greensboro, North Carolina. He also has been president and vice president of business units for AT&T, Lucent Technologies, and director for AT&T Bell Laboratories. Early in his career at Bell Laboratories, Dr. McQueary served as head of the Missile Operations Department for the SAFEGUARD Antiballistic Missile Test Program, based at Kwajalein Atoll in the Marshall Islands. He later headed Bell Laboratories' Field Operations Department in Great Britain in support of a Navy oceanographic research station. He also served as the director of Undersea Systems Development Lab. Dr. McQueary is a former executive board member of the National Security Industrial Association and the American Defense Preparedness Association (ADPA) (combined to form the National Defense Industrial Association [NDIA]). He is a past chairman of the Undersea Warfare Systems Division of ADPA and a former member of the Navy League Industrial Executive Board, the Navy Submarine League, the Electronics Industries Association, the American Society of Mechanical Engineers and the American Association for the Advancement of Science. He is also the recipient of the NDIA Homeland Security Leadership Award. Dr. McQueary is a graduate of The University of Texas, Austin, where he earned a bachelor of science degree in mechanical engineering; master of science degree in mechanical engineering; and a Ph.D. in engineering mechanics as a National Aeronautics and Space Administration (NASA) Scholar (masters of science and Ph.D.) and member of five academic honor societies. The University of Texas has named Dr. McQueary a Distinguished Engineering Graduate.